

Changing New Zealand dairy farm systems

Bruce Greig, Commerce Faculty, Lincoln University

Introduction

There have been dramatic changes in New Zealand dairy farm systems over the last decade. There is evidence that the basic grass dependant dairy farm systems are becoming more intensive with greater amounts of supplementary feed. Basic economic and business principles can explain why this shift is occurring. The study of elementary production economic principles which guide the development of a chosen farm system are explored in this paper.

New Zealand literature has examined different dairy production systems (Hedley, 2006; Newman, 2009) but few have ever done so from an economic imperative. All this literature has failed to mention that the key driver of profit and therefore the choice of farm system is dependent on relative prices i.e. the price of inputs (P_x) vs. the milk price (P_y).

One element of the farm system debate is about high vs. low input. This debate has been part of the dairy industry for decades, both locally and overseas. In New Zealand researchers have concentrated on the scientific principles (animal nutrition and substitution rates) rather than the economic ones. The questions are essentially can farmers make more profit from higher (and sometimes more expensive) feed inputs, and what combination of feed inputs will achieve this, and what are the risks?

A decade of change

New Zealand dairying has undergone some dramatic changes in the last 10 years as shown in Table 1. Herd sizes have increased, so has milk production, stocking rates, land prices and indebtedness.

Table 1. A decade of change in NZ dairying

	1998-99	2008-2009	% change
Dairy Herds	14400	11400	-21%
No. cows milked	3.3m	4.2m	27%
Average herd size	229	364	59%
Average stocking rate	2.5	2.8	12%
Milksolids per herd	70000	120000	94%
National production	880m	1393m	58%
Land Price \$/kg MS	18.4	50.8	176%
FWE/Kg MS	2.13	3.85	81%
Liabilities/kg MS	8.03	19.87	147%
DS:GFR (%)	14.9	28.3	90%

Source: LIC dairy statistics, DairyNZ Economic surveys

Over the same period of time, the terms of trade have also changed and Table 2 illustrates that in recent years there have been major changes from year to year in the input : output price ratio.

Table2. Changing terms of trade

Season	Prices received index	Prices paid index	Terms of trade Index	% change
98-99	1000	1000	1000	
99-00	1045	1023	1021	2.1%
00-01	1396	1114	1253	22.7%
01-02	1526	1168	1306	4.2%
02-03	1171	1199	976	-25.3%
03-04	1162	1191	975	-0.1%
04-05	1274	1229	1037	6.4%
05-06	1216	1303	933	-10.0%
06-07	1211	1342	903	-3.2%
07-08	2054	1480	1387	53.6%
08-09	1520	1558	975	-29.7%

Source: DairyNZ Economic Survey 2008-2009

Although nominal milk payout has increased this has been accompanied by increased volatility (Figure 1) such that the 10 year average milk price has been constant.

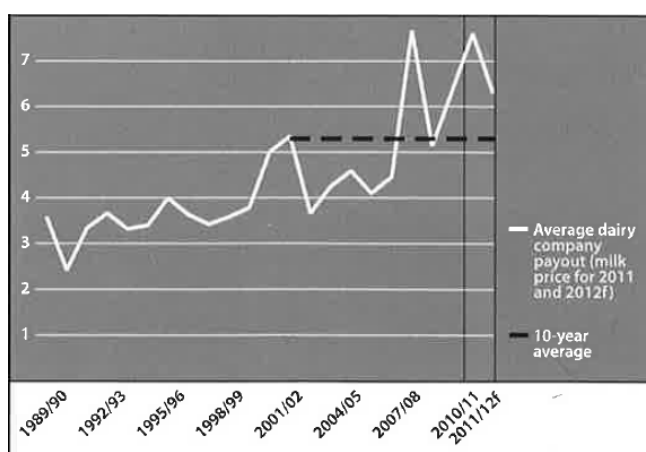


Figure 1. Average NZ dairy payout '99 – '12(f).

Source: Rabobank, 2012, LIC Dairy statistics, 2009

Palm Kernel Extract has become a popular cheaper feed supplement, but its price is highly volatile as shown in Figure 2.

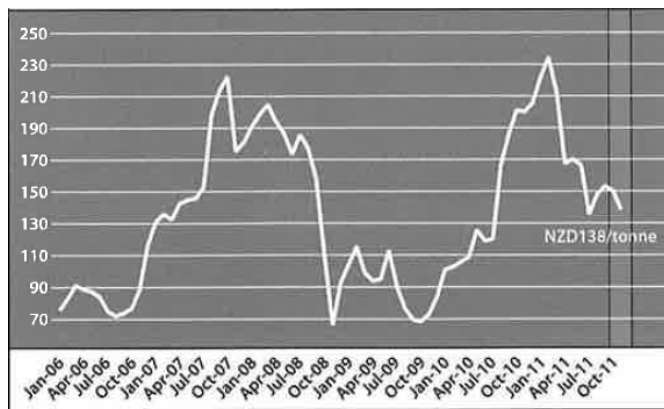


Figure 2. Palm Kernel extract prices

Source: Rabobank, 2012

A major input to NZ dairy farming is fertilizer and these prices have been rising and are also volatile (Figure 3)

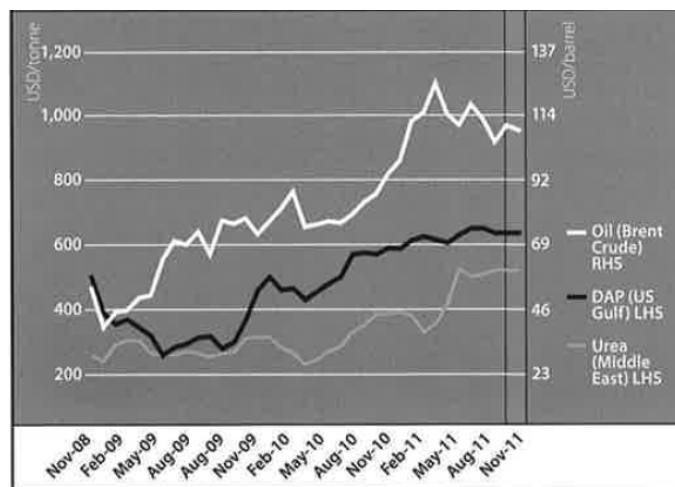


Figure 3. Price movements for Urea, DAP and Oil 2008 - 2011

Source: Rabobank, 2012

The Systems 1-5 classification (Hedley *et al.*, 2006) describes the relative contribution of grazed grass vs. other feed types. In System 1 the predominant source of feed is grazed pasture on the milking platform and with each successive (from 1-5) system the proportion of grazed grass declines.

The changes described above have resulted in a diversification of dairy farming systems, and a system 1 farm is no longer the predominant dairy farm system as depicted in Figure 1. The

largest increase has been in System 5 (300%), followed by System 3 (111%), System 4 (63%). System 2 is largely unchanged but System 1 has decreased by 75%.

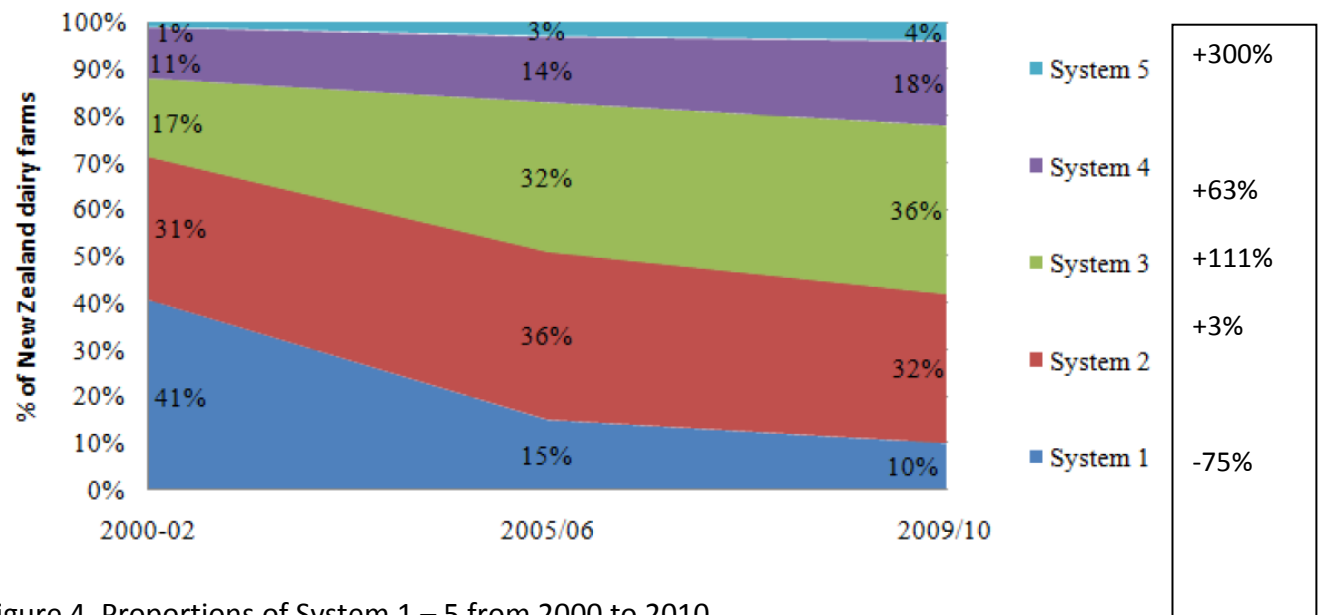


Figure 4. Proportions of System 1 – 5 from 2000 to 2010

Source: DairyNZ Economics Group as acknowledged by Sinclair, 2011

Reasons for the changes

MacDonald *et al.* (2010) acknowledge that a wide range of dairy systems have evolved, from 50% imported feed to 100% pasture, and that this has occurred because of differing farmer goals, skills, knowledge and available resources (Hedley *et al.*, 2006).

They further state that the determining factors for dairy systems are climate, water and feed availability, milk payout and risk. They conclude that the implementation of farm management decision rules is an ever evolving process.

These authors neglect to mention the impact of economics and relative prices as the major determinant of farm systems development, and that farmer's decisions are about responding to changes in the economic environment as well as the biophysical.

Some of the reasons for changing farm systems are:

- (i) Changes in milk price and feed prices (the subject of this paper)
- (ii) Increased volatility of prices
- (iii) Increased land prices
- (iv) Influence of overseas knowledge and expertise
- (v) Changes in farmer values about animal welfare and environmental impacts
- (vi) Farmers seeking new challenges

- (vii) Increased focus on cash operating profit rather than capital gain
- (viii) Changing climatic conditions

Cullen *et al.* (2010) and MacDonald *et al.* (2010) believe that modelling forage systems must be put in a farm management context in order to fully evaluate and understand the impacts on financial performance. As Neal (2010) declares the optimal choice of forages will be influenced by risk (e.g. climate or price variability), also Yates (2010) concurs that variability in pasture growth and milk price creates risk which will affect profitability.

The question Cullen poses is 'can traditional pasture systems meet the forage supply needs of dairy production with changing climate and available water?'

Sinclair (2011) studied the key drivers of profitability for System 5 dairy farms in order to determine appropriate key performance indicators for these systems. She concludes that farmers are motivated to farm system 5 type farms because of:

- (i) Available sources of alternative feed types
- (ii) Higher potential milk production per cow and per hectare
- (iii) Increasing land prices requiring an intensification response
- (iv) Changing prices of milk and feed

Basic production economic principles

Economics is the study of the allocation of resources. In a dairy farming context there are many decisions to be made, e.g. what type of cows, what types and amounts of forage and supplements (inputs), type of milking shed (capital investment), wintering and young stock grazing, the different quantities of inputs, and the amount of milk solids to produce? All these factors comprise the farm system, and most farmers are interested in maximizing the profit from such a system.

Production economics assists in answering the following questions:

What to produce? On a farm we can choose, within limits, what we want to produce for example grain crops, and or lamb meat, milk or flowers. The decision is based on the available resources and therefore suitable land use, and also relative profitability. We study product – product relationships.

How much to produce? What level of yield or production is desirable? Do we want to grow 10 or 20 ton crops, or achieve 400 kg MS/cow or 600 kg MS/cow? We study input – output relationships.

How to produce?

What combination of inputs will help us achieve our targets at the least cost, or optimum profit? For this paper we are considering what combination of inputs, e.g. pasture and supplements and grain and off farm grazing (the farm system), will deliver the greatest profit and or return on investment. We study input – input relationships.

1. Production function – determining the optimum output

The response of milk production (output) to changing levels of feed (input) can be described by the classical production function represented in Figure 5.

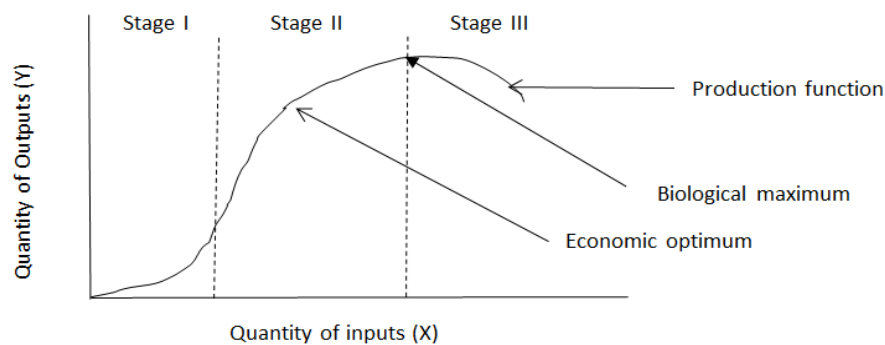


Figure 5. Classical production function

This diagram shows that Yield (Y_1, Y_2, Y_3) is a function of inputs ($X_1, X_2, X_3, \dots X_n$) and describes the efficiency of conversion of inputs to outputs. A key concept is diminishing marginal returns.

For each extra unit of input (say feed) there is a corresponding output (say milk). In stage I output increases with every addition of input. In Stage II output is increasing with each input but at a decreasing rate. In stage III output is decreasing with each additional unit of input.

It makes sense for an efficient farmer to operate in Stage II. But this only represents the physical or biological relationship; exactly where in Stage II is determined by the price of the input and the price of the output. The theory tells us that the profit maximization point will occur where marginal cost = marginal revenue, or where the price line (P_x/P_y) is tangent to the production function (Figure 6).

The consequence of this is that if prices of outputs and, or inputs change, then the profit maximisation point of production changes because relative prices have changed. Also due to changing technology the shape of the production function will also change (Barnard and Nix, 1976)

In New Zealand we know that the relative price of inputs and outputs is constantly changing (Table2), and therefore the profit maximizing point of production changes. Since we do not know with certainty what the milk price will be this makes budgeting difficult.

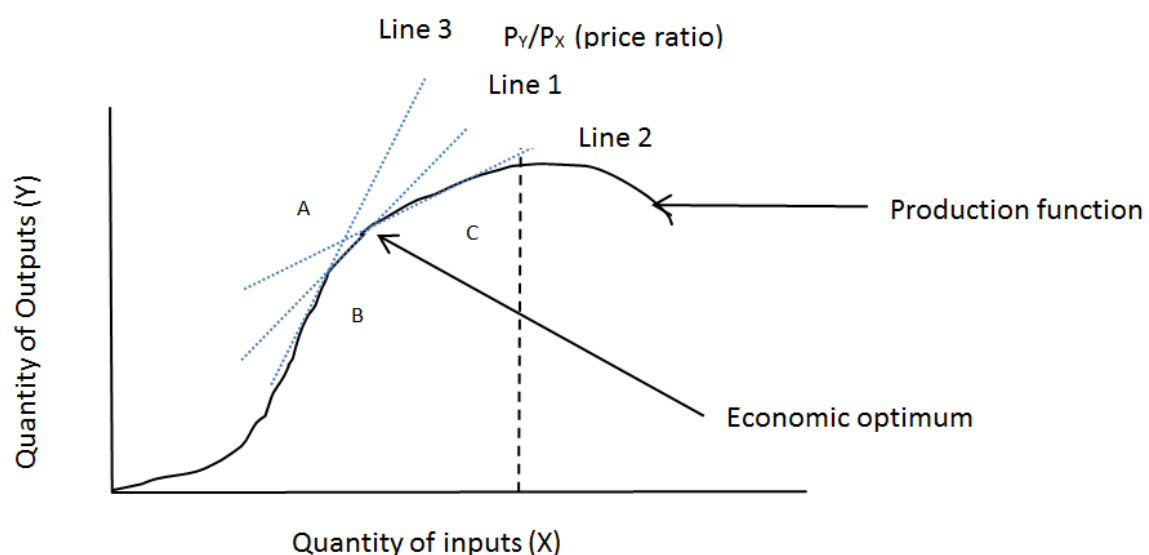


Figure 6. Production function and P_x/P_y

The profit maximizing point when prices are depicted as Line 1 is where the slope of this line is tangent to the production function at Point A in Figure 6. If the price of Y increases relative to the price of X then the slope of Line 2 changes and the profit maximizing point shifts to Point C (a shift up the production function), and if the price of X increases relative to the price of Y then the slope of Line 3 changes and the new profit maximization is at Point B (a shift down the production function). A shift up the production function from Point B to Point C means more inputs are used to produce more outputs.

Simply, if the milk price increases relative to the price of inputs it pays to increase inputs and thus increase milk production.

2. Cost functions – determining the combination of inputs

In dairy farming there is more than one type of feed that cows can utilise, so the next question is what combination of feeds is the most efficient at producing a certain level of output. Currently there are a number of sources of feed available e.g. grazed pasture, conserved supplement, off farm winter grazing, grain, PKE etc.

So now we must consider the input – input relationship. The production function and price line has determined the optimum output level, we must now determine which combination of inputs will achieve this production at least cost. The key concept is the rate of substitution i.e. when more of one input (X1) is used than less of the other inputs (X2) can be used. Figure 7 depicts the shape of the curve that shows for each given level of output there is a combination of inputs.

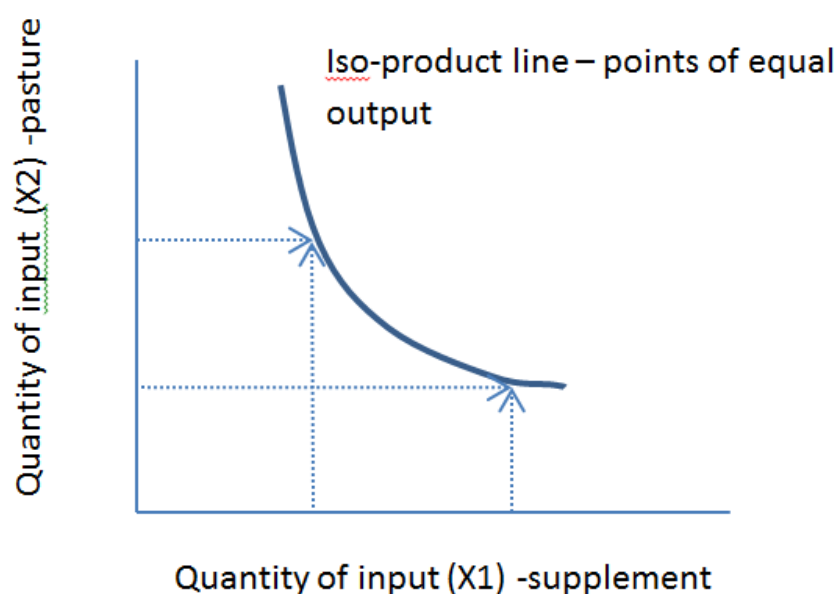


Figure 7. Product contours and input combinations

For a given level of production the product maximization point will occur where the price ratio (P_{x1}/P_{x2}) is tangent to the iso product line. So when prices change so will the profit maximizing combination of inputs. In figure 8, when prices (P_{x1}/P_{x2}) are in the ratio of Line 1 then the profitable combination occurs at Point B, when the ratio changes as in line 2 the profitable combination occurs at point A.

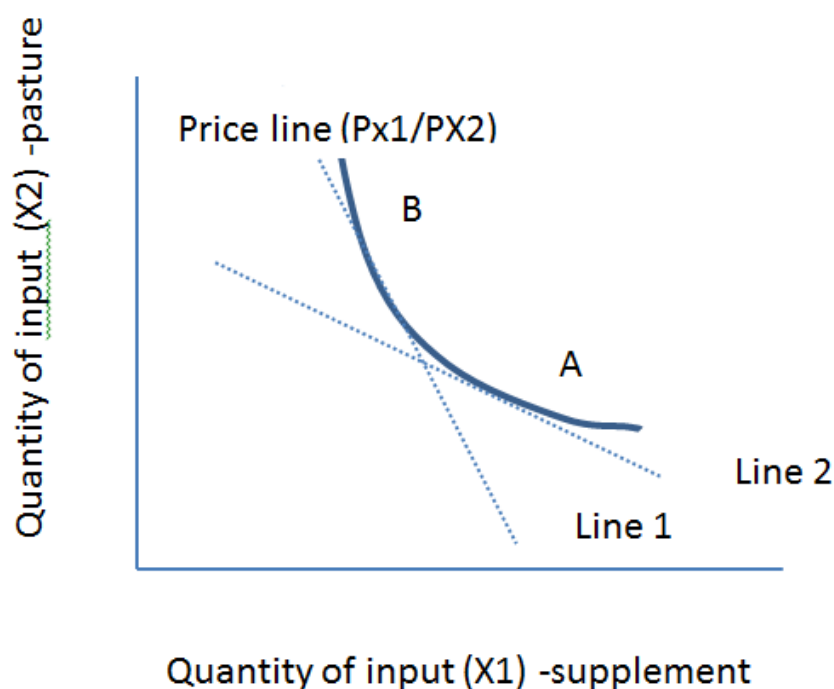


Figure 8. Profit maximization

3. The key messages from production economics

Using the economic framework of production economics the following messages are relevant to the choice of dairy farm systems:

- (i) The milk price and corresponding production costs are used to determine the profitable level of production. When the milk price increases relative to input prices, it makes sense to increase production by using more inputs
- (ii) There are a whole range of combinations of inputs that can achieve this optimum level of milk production
- (iii) The choice of which combination is determined by the relative prices of each input
- (iv) The rate of substitution of one input for the another is crucial in determining the shape of the product curve, and consequently where the profit maximization point occurs

- (v) Since all prices change constantly, the type of system is initially set by expected prices. But these prices change constantly so one asks how easily can the system respond to these risks?
- (vi) A whole farm system has a multitude of inputs
- (vii) When a new or different input is introduced to a system, farmers need to learn how to manage this new combination expertly. Obviously more complex systems require a high level of management (which is another input)
- (viii) The maximizing profit point is determined by biophysical and price relationships, both of which are constantly changing

Risk

Farmers face many sources of risk in their business and desire to be compensated with greater profits if they expose themselves to greater risk. Risk exposure is a major element of farm management decisions, including the type of farm system.

With demonstrated increased volatility in prices and climate, farmers are adjusting their farm systems to mitigate this risk. However some authors believe that increasing supplement use and facing market fluctuations for this input increases risk, while others believe it lessens risk because milk production is more consistent. So farmers might be swapping market risk for climate risk (Shadbolt)

Indoor feeding (intensification) for example might mitigate climate risk but can also have other benefits. According to Judson et al. (2011) and de Wolde (2006) indoor feeding can improve:

- (i) Cow welfare
- (ii) Reduce environmental impact
- (iii) Improve cow performance over winter
- (iv) Improve feed utilization and therefore reduce costs

Cullen et al (2010) believe that dairy systems will need to reposition the forage base in order to be more resilient in response to changing climate.

Conclusions

It is understandable that with changing product prices (the milk price) and input prices (feed costs) farmers who all have different objectives will respond to these changes and elect a farm system that maximises their profit and utility.

Higher input systems may provide more consistency in production but these systems can also be more complex to manage (Hedley, 2006). Newman and Savage (2009) have also shown that type of system is not a good indicator of profitability. Different farming systems can be profitable in their own right; rather management ability is the key driver.

The choice of farm system is also influenced by a farmer's level of risk aversion. Changing farm systems in NZ is also an attempt to mitigate risk. Since farm systems design is so complex these issues and principles will continue to be debated.

Production economic principles demonstrate that management and system decisions should be based on physical production relationships and the relative prices of inputs and outputs. In the current economic climate these prices are constantly changing, and farmers are desiring resilient farm systems that can weather the downturns but also capture the opportunities of the upturns.

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